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Evaluation for Post Reclamation Land Use at the Jackpile Mine Area

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by

Frances Andazola

and

CeCilia Sadler

for

Professor Wm. Paul Robinson

Independent Study
Community & Regional Planning
University of New Mexico
Albuquerque, New Mexico

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Acknowledgements

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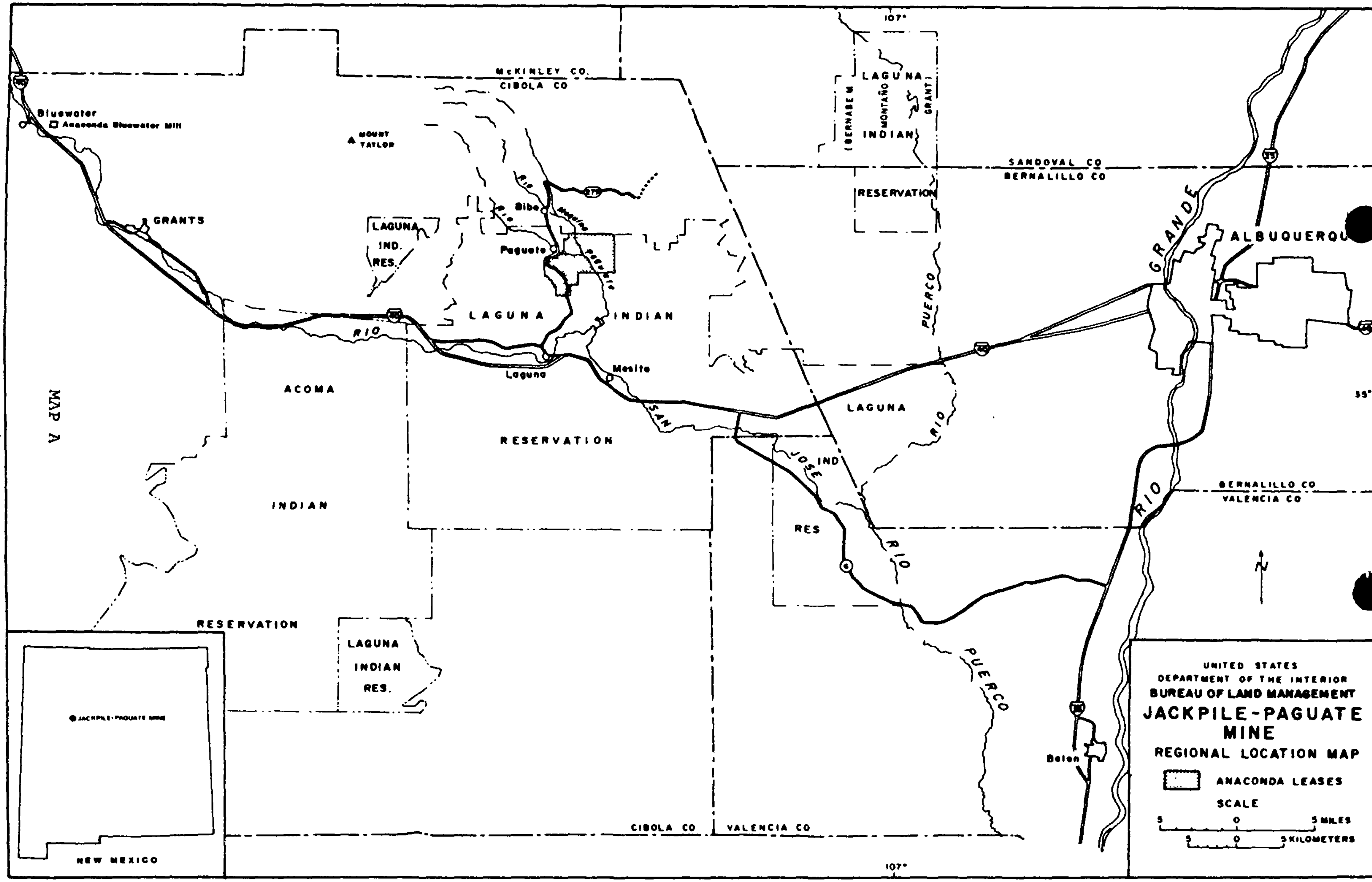
Abstract

This report was prepared to meet requirements for an Environmental Evaluation class supervised by Professor Paul Robinson. The goal of the report is to organize information in an examination of possible land uses after the reclamation of the Jackpile-Paguate mine site has been completed. The reclamation process and the possible risks in the use of the reclaimed land are examined. This report is based on the Final Environmental Impact Statement (FEIS), Cost Optimization on the Jackpile-Paguate Reclamation Program by the Jacobs Engineering Group, Inc., a study requested by the Laguna Pueblo to assist in the development of a reclamation plan and the Record of Decision (ROD), the official plan for reclamation. Other studies include examinations of soil, vegetation, and livestock in areas contaminated by uranium mining and milling activities, fallout, and low level waste.

The use of reclaimed land by humankind and the possible health risks associated with its use cannot be fully explored under the time constraints of one semester. Few long term studies have been completed. Thus, this report only touches upon relevant information and clarifies the need for long term study and monitoring at the Jackpile-Paguate mine site and the Paguate Reservoir.



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Introduction

The Jackpile-Paguate mine site is located on the Laguna Pueblo, 40 miles west of Albuquerque (Map A). In a series of three leases with the Laguna Pueblo beginning in 1952, the Anaconda Minerals Company, a division of the Atlantic Richfield Company, expanded operations to include 7,868 acres of land. Mine operations included 1,015 acres of open pits, 1,266 acres of waste dumps, 103 acres of protore stockpiles, and 32 acres of topsoil stockpiles. 240 acres held support facilities and depleted ore stockpiles (FEIS, 1986, pg. 1-1.) When the mine closed in March of 1982 because of a depressed uranium market, it had expanded to the edge of the Village of Paguate. The terms of the mining lease and Federal regulations required that the mine be reclaimed.[1] A financial agreement between Anaconda and the Laguna Pueblo was made. Plans for the reclamation were made according to the funds available.

What follows is a brief description of the reclamation process and potential concerns associated with use of the reclaimed land. Traditional and current land use options are considered and an evaluation of the health risks associated with exposure to radiation and other contaminants. Finally, this report offers a few practical approaches to protection from radioactive contamination.

Section I

The Reclamation Process

Soil Cover

From 1987 through 1989, the Jacobs Engineering Group was employed by the Laguna Pueblo to develop a reclamation plan. As part of the reclamation plan prepared by the Jacobs Engineering Group, Inc., a minimum thickness of Mancos shale and topsoil was recommended to cover the waste dumps and pit bottoms of the Jackpile-Paguate mine site. Through the use of a computer model, it was determined that "one foot of Mancos shale and two feet of soil would provide the desired radon attenuation from ore-derived wastes inside pit areas. One foot of Mancos and 1.5 feet of soil would be adequate to cover ore-associated wastes outside the pit areas."[2] Again, through the use of a modeling system, these minimum cover thicknesses were predicted to meet the post-reclamation Record of Decision (ROD) standard. The standard required that radon measurements should be less than 3 picocuries per liter (pCi/l) of air plus the background level of .5 pCi/l when averaged over 3 principal areas of the mine site. This means that radon concentrations will vary over the minesite but will meet the average required by the ROD. In practice, 1 foot of Mancos shale and 1 1/2 feet of topsoil is used to cover the dumps and pit bottoms (Jim Olsen, Jackpile-Paguate Reclamation Manager).

A difference of a half-foot exists between what was recommended by Jacobs Engineering Group for the pit bottoms and what has been and is being done. Despite the discrepancy of a half-foot of soil between what was recommended by the Jacobs Engineering Group for the pit bottoms and what has been and is being done, Mr. Olsen reports that radon measurements over the entire mine site average 1 pCi/l and range from .3-2.5 pCi/l (1 pCi = about 2 decays per minute) and that between the mine site and the village of Paguate there are 15 monitoring sites.

This average is below the 3 pCi/l average required by the ROD for radon gas. The gamma radiation standard set by the ROD is twice the background amount which at Laguna Pueblo adds up to 28 uR/hour (microroentgens per hour). Mr. Olsen reports these levels to be under standard as well. Measurements are made quarterly and verified by Eberline Analytical Company of Albuquerque. Any requests for information should be directed to Governor Harry Early of the Pueblo.

According to these measurements, the combination of 1 foot of Mancos shale and 1 1/2 feet of topsoil over mine pits and waste dumps seems to provide adequate protection for people and animals from exposure to direct gamma radiation and inhalation of radon gas. The possible effects of various erosive factors upon this layer of Mancos shale and Tres Hermanos sandstone will be discussed later in this report.

Vegetative Cover

The next step in reclamation is revegetation of the mine site. Revegetation is done in an effort to stabilize waste dumps from erosion, visually blend the mine site into its surroundings, and support the possibility of livestock grazing on the reclaimed land.[3] The ROD specifies that the vegetation reestablished on the mine site will "consist mainly of native plant species possessing qualities compatible with post-grazing use and adapted to local environment." There are two seed mixtures. One for fine-textured, sandy soils and the other for soils with 20-50% rock content. Mix 1 is composed of blue grama, sideoats grama, galleta, Western wheatgrass, alkali sacaton, fourwing saltbush, yellow sweetclover. Mix 2 contains alkali sacaton, sand dropseed, Indian ricegrass, sideoats grama, blue grama, little bluestern, fourwing saltbush, winterfat and yellow sweetclover. Additional vegetation known to grow in the area on mesa slopes and tops are woody plants like one-seed juniper, feather indigobush, soaptree yucca, winterfat, and rabbitbrush. Other grasses include feathergrass, red muhly, red threeawn, bottlebrush squirreltail and wolftail. Forbs include fleabane daisy, four 'o clocks and cutleaf primrose, wild buckwheat, pinque, plains blackfoot and stickleaf.[4] These other native plants, by the distribution of seeds by wind and animals, may become part of the revegetated surface.

The success of revegetation on the reclaimed area will be based on the percentage of plants present compared to undisturbed areas on the Pueblo. At least "90% of the density, frequency, foliar cover, basal cover, and production of undisturbed references areas" must be present. The ROD stipulates that a determination of the vegetation's success at reestablishing itself will not be made "sooner than 10 years following seeding" and "Livestock grazing will be prevented until 90 percent comparability values are met."

(ROD, 1986, pg. 7) According to Jim Olsen, the progress of revegetation will not be checked until after the third growing season.

Erosion

The following description of weather conditions at Laguna Pueblo are summarized from the FEIS. The temperature range is from the mid-30s in winter averaging in the upper 80s with occasional maximums over 100 degrees in the summer. Mean precipitation in a year is 9.07 inches with 61% of precipitation occurring as rain from June to September from short, intense rainstorms. Wind speeds are light to moderate but strong winds may accompany thunderstorms and winter and spring storms. Winds are from the southeast and northwest with the stronger winds being northwesterly. In comparison to desert and even humid environments "erosion is relatively high in semiarid areas" because rainstorms are often of high intensity leading to flashfloods and erosion.[5] Thus, the comparatively high erosion of semiarid environments must be weighed when estimating the longevity of the protective cover. Other contributors to erosion include the displacement of soil caused by the movements of livestock herds over the topsoil and burrowing animals. In one study of pocket gophers at a low-level waste (LLW) site in Los Alamos, about 12,000 kilograms (kg) of soil per hectare (ha) was displaced during a fourteen-month period. This speeds up the erosion of the protective topsoil by wind but slows erosion by water runoff because of the rougher topsoil surface created by burrowing animals. At the same time, entrances to and tunnel systems created by burrowing animals provide voids or spaces where water can enter the topsoil and percolate downwards. Since evaporation at the site is great enough to result in a "net moisture deficit" (FEIS, 1986, pg. 2'62) the probability of the water percolating down and through the uranium ore-bearing waste and into ground water is limited.[6] Prairie dogs, rabbits, gophers, and other rodents and lizards are present on the Laguna Pueblo.(FEIS, 1986, pg. 2'74.) The ability of some of these animals to dig through the Mancos shale and possibly bring ore-bearing waste to the surface requires further study. At LLW sites, burrowing animals have excavated radionuclides and brought them to the surface just as they would soil.[7] Once on the surface redeposited contaminants have the potential of becoming airborne or transported by rain to areas where livestock and wildlife may drink (surface ponding, reservoirs) and heavy metals, uranium and its decay products can contaminate the water and accumulate as sediment. This is a possible radiation pathway to humans by consumption of livestock and wildlife using these water sources.

The elements of erosion discussed above reveal the dynamic nature of ecosystems and climates like that of Laguna Pueblo. The relative importance of one erosive factor over another and its overall impact upon an environment is not fully known. Yet, since protection from gamma radiation and radon gas is dependent upon the thickness and integrity of the protective cover at the Jackpile-Paguate mine site, very long-term monitoring of the effects of erosion on this cover is important.

Vegetation, Livestock, and Water Studies

While vegetation provides the benefits of erosion control and food for livestock, these benefits are tempered by the possible penetration of plant root systems through the shale cover, into the ore-bearing wastes, and the intake of radionuclides and heavy metals into the plant. It has been shown that "deep-rooted plants can access buried radionuclides and bring them to the surface of the site (Foxx et al., 1984).[8] In response to this possibility, the ROD requires that "Vegetation will be sampled annually for radionuclide and heavy metal uptake in the pit bottoms" (ROD, 1986, pg. 7). The specific capabilities of the Laguna native plant species to penetrate the protective Mancos shale cover on waste dumps and possibly take contaminants into their systems deserves monitoring as well. The intake of contaminants by plants also creates a means by which these substances can be redeposited onto the surface. When vegetation dies and decays substances contained in the plant will be left on surface soils exposed to erosion.[9] The possibility of affected vegetation being eaten by livestock, game, and wildlife creates a radiation and heavy metal pathway for anyone who consumes these animals.

A study of soil, vegetation, water, and cattle near uranium mining and milling facilities in Ambrosia Lake, New Mexico, just northwest of Laguna Pueblo, revealed elevated radionuclide levels in all four elements. The study was conducted because of the great number of uranium mines and mining related activities in the Grants Mineral Belt and concern about health risks to the region's population. According to the authors, "Few studies have addressed radionuclide concentrations in domestic animals raised near U mines or mills. Yet, evidence from two previous investigations indicates that there may be radionuclide contamination of the food chain leading to humans by the U mining and milling industry."[10] What has been learned from that study is applicable to livestock grazing on the Laguna Pueblo since land use, soil make up, vegetation type, and the type of radionuclides potentially present are identical.

In the Ambrosia Lake study, in addition to exposed samples, control samples of soil, plants, and water were collected. These control samples were not near nor had they been exposed to uranium mining and milling activities. Also, three groups of cattle were studied. The control group, consisting of 10 cows, was taken from an area near Crownpoint because it is most like the Ambrosia Lake area yet no above ground uranium mining has taken place there. Five cattle were designated as Group 1 and five as Group 2. The Group 1 cattle were taken from an area that had been frequently flooded by water pumped from the uranium bearing geological formations (dewatering effluent) of the mine site near Ambrosia Lake. Cattle from Group 2 grazed in a larger area and had access to both surface ponds as well as dewatering effluent. Analysis of the samples was done by Eberline Corporation in Albuquerque and for quality control purposes also by EPA-Environmental Monitoring Systems in Las Vegas, Nevada. Methods of measurement were guided by EPA and U.S. Department of Energy procedures. The results of the study showed that "cattle exposed to U mine and milling discharges and wastes had elevated tissue radionuclides, compared with controls" and that "findings support the conclusion that the elevated radionuclide levels found in cattle tissue from Ambrosia Lake resulted from the cattle's exposure to radionuclide byproducts of the U mining and milling industry." Although it is not possible to determine exactly what percentage of contamination was contributed to by each element in the cattle's environment, the authors of this study conclude that "Further environmental sampling and measurements of tissue radionuclide concentrations in animals exposed only to dewatering effluents, or to mill tailings, would be needed to identify the relative contribution from each source. Until these studies are completed, restricting access of livestock to U mine dewatering effluent and to land that has been irrigated with mine water--or is in proximity to mill tailing--would markedly reduce the probability of food chain contamination." All soil, vegetation, and water collected from the Ambrosia Lake area had elevated levels of radionuclides as well.

In the same study, cancer risks from ingestion of contaminated cattle over a one year period were estimated in an attempt to foresee health risks to residents of the area. Three possible situations were modeled in order to estimate these risks and considered the consumption of cattle from each area. Scenario One assumed that each individual in a family would eat 74 kg of meat (the average meat consumption in the United States per person) including the liver and kidneys. Scenario Two assumed that a person ingested 78 kg of muscle and no liver or kidney. Scenario Three, a worst case estimate, assumed that a person ate higher percentages of liver and kidney.

Deaths from cancer for Scenario One are - one chance in 1,640,000 from ingesting control beef, one chance in 1,180,000 from eating Ambrosia Lake Group 2 cattle, and one chance in 350,000 from eating Ambrosia Lake Group 1 cattle. Continued consumption of Group 1 cattle for 20 years would increase the cancer mortality risk to one chance in 18,000. In Scenario Two, where no liver and kidney were eaten, the risk of eating cattle from Group 1 decreased by 55%. Scenario Three revealed that eating a high percentage of liver and kidney raised the risk of death by cancer. Consumption of Group 1 cattle showed results of one chance in 150,000 and for Group 2 cattle, one chance in 500,000.

The authors conclude that "the health risk to the public from eating exposed cattle is minimal, unless large amounts of this tissue, especially liver and kidney, are ingested." Thus, if the liver and kidney is a staple of the Pueblo diet a significant risk exists. The liver and the kidney of cattle absorb greater amounts of radionuclides than other parts of the body. Generally, animals with multiple part stomachs such as cattle, goat, deer, and antelope will have higher levels of contamination than plant eating animals with single unit stomachs. When considering game, small mammals because of their rapid metabolic rate and carnivores because of their place in the food chain will have higher levels of contamination. Contaminants accumulate in the highest mammal in the food chain-humankind being at the top of the food chain.[11]

When comparing the results of this study to possible contamination of cattle at Laguna Pueblo, the following limitations and similarities must be considered. Understanding the limits of the study and the elements it shares with the Laguna Pueblo will be helpful in understanding the connection between the two situations and the possible radioactive contamination of livestock and game at Laguna Pueblo. Limitations include 1) only a small number of cattle were tested from each area; 2) the level of contamination in the soil, vegetation, and water collected may not have accurately reflected the level of contamination that the cattle were actually exposed to (the period of time study cattle grazed in this area varied from 2-7 years and the levels of contamination present may have varied too); 3) the study cattle may have actually drank water with much higher radionuclide levels than given in the report; 4) standard errors were large and; 5) the results of the split sample testing varied. For example, it is possible that levels of the uranium decay product Polonium 210 could be twice as high as the true values. Thus, the results of the study cannot be considered representative of the level of radionuclides present in all animals in the area. Also, Laguna Pueblo has had no uranium mill tailings stored on the mine site.

Important similarities are 1) land use, 2) soil and vegetation types, 3) contaminants identical to those potentially present in environmental elements at Laguna pueblo, and 4) livestock's (and game's) access to water from the mine site.

Since soil and vegetation types are alike we can reasonably expect contaminants to behave similarly in environmental elements and animals. For example, in 1979 radioactivity was measurable in vegetables at Laguna Pueblo (FEIS, 1986, pg. 2'46). However, the conditions existing then, during mining, and now with a great portion of the reclamation completed are different. Current studies of vegetation and livestock specifically from the area near the Jackpile-Paguate mine site would be helpful.

A closer examination of the environmental element, access to water from the mine site, that is shared by the affected livestock from the Ambrosia Lake area and possibly livestock from Laguna Pueblo is warranted. Over the lifetime of the mine site, the Rios Paguate and Moquino, in combination with natural erosive processes such as run off and arroyo headcutting, have carried soil downstream from the minesite to the Paguate Reservoir. The 1986 FEIS uses a conservative process to estimate that since 1952 the volume of deposited sediment in the reservoir is 620 acre-feet or 22 acre-feet per year (FEIS, 1986, pg. 2'58). Along with soil not associated with uranium, uranium ore (and, thus, its decay products) and heavy metals will have also been deposited. Tables 2-15 and 2-24, below, from the FEIS shows, respectively, 1981 gamma exposure rates at Paguate, 1983 radium and uranium levels at Paguate, and an 1982 aerial gamma radiation survey of the mine site and surrounding area.

TABLE 2-15

GAMMA EXPOSURE RATES AT PAGUATE PRESERVOIR
(microroentgens per hour)

Exposure Rate	Percentage of Reservoir
Less than 10	22
11-20	47
21-30	27
Greater than 30[a]	4

Source: Eberline Instrument Corporation 1981.
Note: [a]The maximum rate measured was 47 microroentgens per hour.

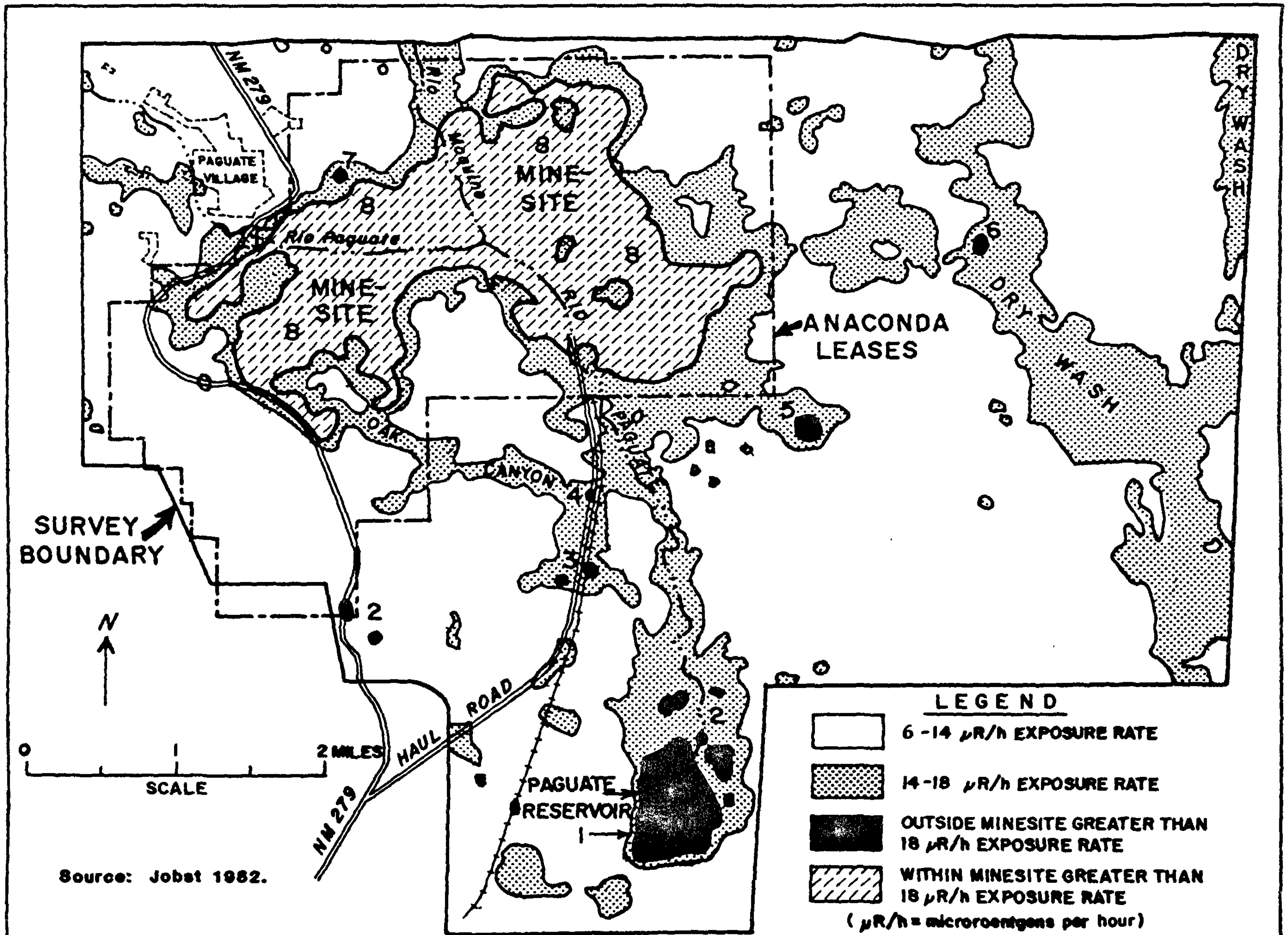
TABLE 2-24

RADIUM AND URANIUM IN SURFACE WATERS IN AND NEAR THE MINESITE

Location	Ra-226[a]	Natural Uranium[b]
Rio Paguate (upstream)	0.35	0.006
Rio Moquino (upstream)	0.28	0.008
Ford Crossing (downstream)	3.73	0.239
Paguate Reservoir	1.03	0.236

Source: Momeni, et al. 1983.

Notes: [a]Measured in picocuries per liter.
[b]Measured in milligrams per liter.



Aerial Gamma Survey of the Minesite and Surrounding Area

These charts are, at least, ten years old and change has occurred. Specifically, the gamma radiation readings represented by the aerial survey which surround the Paguate Reservoir will have decreased due to the positive efforts of the Jackpile-Paguate Reclamation staff and crew. However, long lived radioactive elements like uranium and radium and gamma radiation at Paguate Reservoir will have increased due to the continued build up of sediment.

The sedimentation at Paguate Reservoir which has caused a build up of uranium associated contamination, presents the clearest risk to animal and human health since ranching is one of several traditional occupations that remains in place. Currently, there are approximately 2500 head of cattle on the Laguna Pueblo-not all have access to Rio Paguate and Paguate Reservoir downstream from the mine site. There is one sheep rancher along the Concho Valley. The valley extends from the southern tip of the minesite, along the Paguate River and down to the Paguate Reservoir (per conversation with Nolen Duomo). The cattle and sheep that graze in the Concho Valley and the health of people that consume these cattle and sheep may be at risk.

Post-Reclamation Land Uses

The ROD summarizes possible land uses for the reclaimed mine site. They conclude that "Limited livestock grazing, light manufacturing, office space, mining and major equipment storage will be allowed. Specifically excluded are habitation and farming."[12] Although the ROD does not describe what is meant by limited livestock grazing, erosive factors contributed by cattle and sheep, burrowing animals, the natural erosive processes of a semiarid climate, and the consequent concerns about radioactive exposure places limits on how extensively the reclaimed land can be used.

Other options, the placement of light manufacturing, office space, or stored equipment on the land will require access to utilities, road improvements, and other investments in the physical structure of the site in order to make it functional. Currently, according to Richard Luarke, Tribal Planner, the pueblo does not possess the funds to make the necessary improvements. This does not necessarily close this option off to the Pueblo. Dependent upon the amount of investment required to make the site functional, any remaining reclamation funds could be applied to this purpose. Also, if the Pueblo desires, incentives such as low rent or other incentives can be offered to outside investors in exchange for their investment in the improvement of the site. This use of the reclaimed mine site would eliminate topsoil erosion due to livestock's movement on the surface of the land and paved roads would eliminate erosion due to vehicular traffic. Yet, people occupying these commercial spaces are still at risk to any exposure caused by the other erosive factors already discussed.

Currently, there is a moratorium on mining on the Laguna Pueblo (conversation with Lloyd Pino, Mesita Council Member). If the price of uranium increases to a profitable level, the incentives for mining the remaining uranium must again be measured against the impact on the environment as well as the social structure of the Pueblo. If this question arises again, the Pueblo now has a wealth of experience to base their decision on. Larry Chalis, speaking at the Southwest Indigenous Miner's Conference at Paguate Village[13] described some the social impacts of mining upon the village. For example, during mining, traditionally prepared fruits - sun dried - were exposed to uranium bearing dust from the mine site. That method of preparation had to stop. The traditional annual hunt was also effected by the retreat of game from mine activity. The structure of the hours of work required by Anaconda placed hardships on families and traditional methods of worship. Religious practices that required 4-5 days away from work were difficult to participate in since work hours conflicted with that amount of time away from work. Another hardship was experienced by families employed by the mine when shift hours did not match. For example, one parent may be arriving from work while the other was leaving. This left little time together with each other or children. Also, the generation that grew up working the mine lost opportunities to learn the once common practice of farming. Now, according to Richard Luarke, the current younger generation has little interest in farming.

At the conference, various village members expressed concern with the future possibility of mining. One village member asked if the Record of Decision could be amended to emphasize reclamation as opposed to future mine use. The sentiment expressed at this meeting does not seem to support the possibility of mining as a land-use option. However, the experience gained by the Pueblo will assist them in determining the social impacts of commercial development of the reclaimed mine site as well.

Due to the natural dynamic processes in the ecosystem of the mine site and surrounding areas, considerations for any future land use must examine change and how that might effect the reclamation. Another dynamic component is the culture. Any land use development in the area must consider the long history of cultural traditions.

Section II

Ground and Surface Water; A Closer Look

The purpose of this section of the report, is to assess the characteristics of the groundwater and surface water located in the Jackpile Mine and Mesita Reservoir area. Information presented here, is an evaluation of readily available literature regarding the Jackpile Mine area. Additionally, personal testimony gathered while interviewing Laguna Pueblo residents, is included where relevant to the subsection. The readily available information was accessed through several Federal Documents to include the Environmental Impact Statement Draft and Final, Water Resources on the Pueblo of Laguna, West-Central New Mexico, and Hydrology and Water-Quality Monitoring Considerations, Jackpile Uranium Mine, Northwestern New Mexico. Each of the documents reviewed is listed in the Bibliography. Since the goal of this section of the paper is to evaluate ground and surface water factors, one basic subsection within this section pertains to the geology of the area, with description of the water bearing units. It is necessary to include fundamental geological composition, which, in turn correlates to the amount of water and quality of water naturally occurring. These two points are critical in evaluating land use after the reclamation process has been finalized.

Topographical Features pertaining to Ground and Surface water

The area of the Jackpile Mine leases is an area situated along two perennial rivers and in the foothill region of the San Mateo

Mountains (refer to Map 1). Elevations within the mine lease boundary range in altitudes from 5,820 to 6,910 feet. Several prominent topographical features surround the Jackpile mine site. On the northwest side, the San Mateo Mountains frame the mine area. Mount Taylor is the highest peak, raising to 11,300 feet, and located 15 miles from the mine site. Wheat Mountain (7,140) is the highest feature on the southwest side of the mine site. Other topographically high areas contributing to the surface hydrology in close proximity to the mine area are the drainage divides located southeast of Mesa Chivato and west of the mine site. Gavilan Mesa is a prominent topographical feature located at the northeast corner. In the region south of the mine area are North and South Oak Canyon Mesas. Several unnamed mesas raise to prominent but undistinguished heights in the vast openness. From the village of Paguate, one can see jutting mountain peaks, contrasting mesas, and several piles of seemingly groomed earth. The "groomed" pilels are waste rock and stockpiled ore which range in height from 50 to 200 feet. From a high point, one can see two huge depressions in the earth's surface. These are pit areas which sink 200 - 300 feet below the surrounding land surface.

The Rio Moquino and the Rio Paguate are two perennial rivers meandering from the origin in the San Mateo Mountains. Rio Moquino enters the mine area on approximately the north side, the Rio Paguate enters on the northwest side. Rio Moquino joins the Rio Paguate in approximately the middle of the mine area. From the mine region, the Rio Paguate flows southeasterly into the Mesita Reservoir. Drainage area of the Rio Paguate above the Jackpile mine region is 107 square miles (EIS, final p2-46).

The Climate in northwestern New Mexico is characterized by minimal precipitation and significant evapotranspiration (USGS #85-4226). Climate classification is semiarid with an average annual rainfall in the area is 9.7 inches (EIS, final)..

Rainfall has been more unpredictable then in the past in this semiarid climate. Three major storms carrying heavy precipitation have occurred since 1988. "We aren't sure which was the 50 year flood or the 100 year flood," commented Nolan Duermo, Reclamation Manager. Reportedly the storm of 1993, was localized directly over the mine area, with surrounding areas not receiving any rainfall (Rudy Lorenzo, Reclamation Project Crew Foreman, interview).

I. Geological Description of the Jackpile Mine Area

(The following information is summarized from the Risser and Lyford USGS Report 83-4038, section on 'Ground Water with Geology' from the EIS, final 1986).

The stratigraphy of formations in the area of the Jackpile Mine range in age from Late Cretaceous through to Triassic (Please refer to Figure 1 for this section).

SYSTEM	FORMATION OR GROUP	MEMBER OR TONGUE	THICKNESS (feet)
CRETACEOUS	Point Lookout Sandstone of Mesaverde Group	Hosta Tongue	100
CRETACEOUS	Crevasse Canyon Formation of Mesaverde Group	Gibson Coal and Dalton Sandstone Members	400
CRETACEOUS	Mancos Shale	Mulatto Tongue	400
CRETACEOUS	Crevasse Canyon Formation	Dilco Coal Member	85
CRETACEOUS	Gallup Sandstone of Mesaverde Group		80
CRETACEOUS	Mancos Shale		750
CRETACEOUS	Lower part of Mancos Shale	Includes three sandstone tongues of Mesaverde Group	270
CRETACEOUS	Dakota Sandstone		50
JURASSIC	Morrison Formation	Jackpile sandstone (economic use)	200
JURASSIC	Morrison Formation	Brushy Basin Member	270
JURASSIC	Morrison Formation	Westwater Canyon Member	50
JURASSIC	Morrison Formation	Recapture Member	40
JURASSIC	Bluff Sandstone		300
JURASSIC	Summerville Formation		90
JURASSIC	Todilto Formation		10
JURASSIC	Entrada Sandstone		120
TRIASSIC	Chinle Formation		

EXPLANATION

SANDSTONE

CARBONACEOUS MATERIAL

SHALE AND MUDSTONE

ANHYDRITE AND LIMESTONE

Source USGS #85-4226

Figure 1

Cretaceous

The Cretaceous Period in this area consists of inter woven layers of Dakota Sandstone, Mancos Shale and the Mesa Verde Sandstone. Water bearing units in the Cretaceous period are the Dakota and Mesa Verde Sandstone Groups. Units in the Cretaceous system with the greatest water bearing capacity are the Dakota and Mesa Verde Sandstone. Risser and Lyford describe Dakota Sandstone as four, fine - to coarse - grained, well consolidated sandstone beds separated by intertwining beds of Mancos Shale. Water from the Dakota Sandstone and Mesa Verde Formations yield approximately less than 15 gallons per minute (gpm). Wells pumped from this formation are generally used for stock consumption because of higher concentrations of dissolved solids and lower average gallons per minute retrieved.

Water recharge to the **Cretaceous** units is predominantly from stream flow and precipitation. Cretaceous units discharge to the Rio Moquino and the Rio Paguate through spring runoff. Seepage occurs to underlying geologic units.

Jurassic

The Jurassic Period (highlighted in Figure 1) in the area consists of Entrada Sandstone, Todilto Formation, Summerville Formation, Bluff Sandstone and Morrison Formation. For this section, the more significant water bearing units are summarized, those being units within the Morrison Formation.

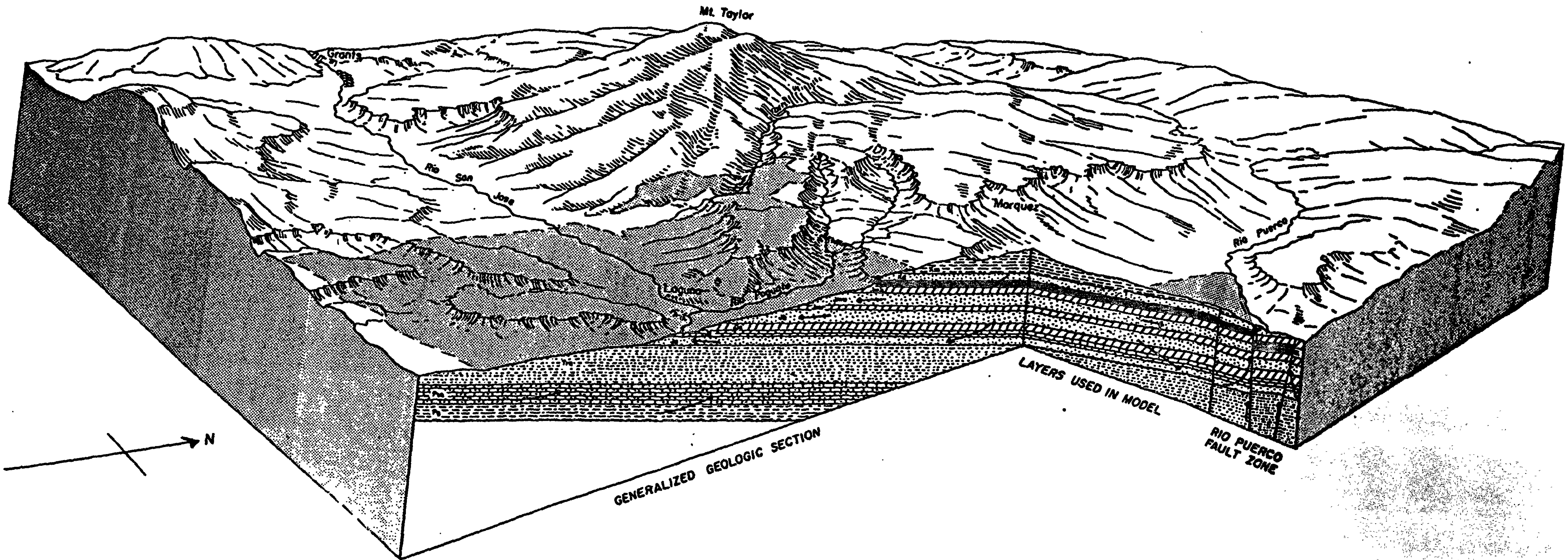


Figure 2

[DARKENED LAYER IS THE JACKPILE SANDSTONE]

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The Morrison Formation in the mine area is divided into three members and one informal unit. The three members are the Recapture Member, Westwater Canyon Member and Brushy Basin Member, and the informal unit is the Jackpile Sandstone. Principal water bearing units in the Morrison Formation are the Westwater Canyon Member and sandstones in the Brushy Basin Member, which include the Jackpile sandstone. Water pumped from these members produce water for domestic, industrial, and stock uses at rates averaging 30 gpm.

Jurassic units in the area of the mine receive recharge by precipitation to exposed outcrops as well as leakage to from the overlying Cretaceous sandstones. Some discharge from this unit is released by seepage into the merging rivers, approximately at the mine site (Risser and Lyford, pg. 31). (Refer to figure 2, darkened area).

Triassic

The Triassic system in the area of the Jackpile Mine consists of siltstones and mudstones of the Chinle Formation (reddish-gray). This unit is reported to yield only occasional aquifers of local importance.

Recharge to units in the **Triassic** age are through precipitation on outcrop areas. Seepage occurs upward from the Permian rocks (Risser and Lyford, pg. 31).

Some Comments of Tertiary and Quaternary Deposits

The Tertiary member is compiled mainly of basalt flows from Mount Taylor. Sources of water located in this layer are from six springs located immediately in the area of Mount Taylor. Additionally, precipitation contributes to recharge within this unit. Water from this layer is hypothesized to contribute some recharge to Paguate Creek. Additionally, there are deposits of late or in the Quaternary period, in the alluvium fill of the Rio Paguate and the Rio Moquino. Relationship to water flow and recharge is shown in figure 3.

B. Pit Backfill

A more recent "formation" in the area of the Jackpile Mine is the pit back fill deposit. It consists of protore, waste dump material and excess material from waste dump re-sloping and stream channel clearing (Record of Decision, December 1986) Additionally, it was reported that the homes built to house the mine workers during mine operation were broken down and filled into the north pit.

The Record of Decision (ROD), states in the section titled "Pit Bottoms", the following:

> . . . "the pits will remain as closed basins. . . . Additional backfill will be added as necessary to

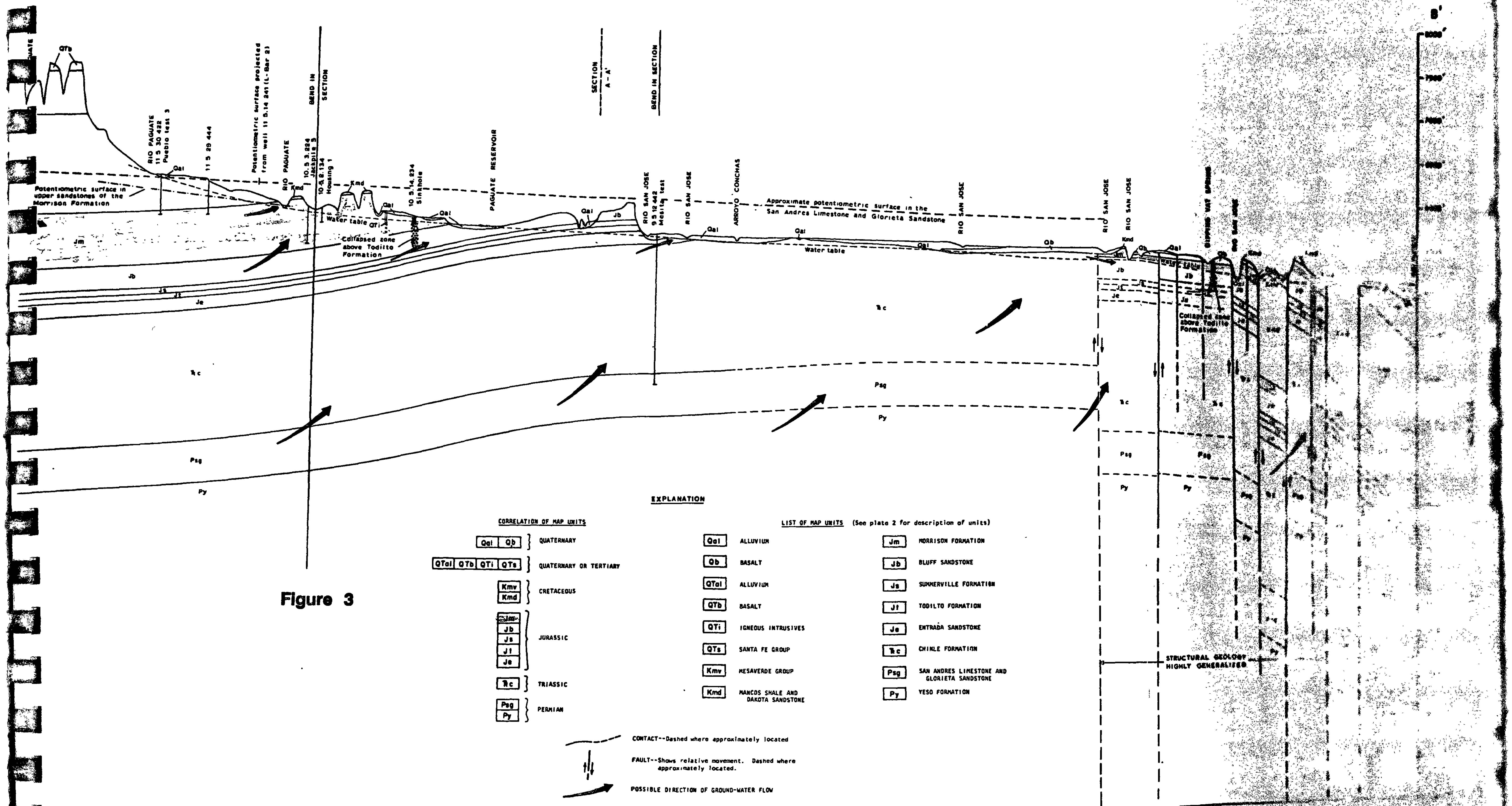
B'
8000'
7000'
QTb
RIO PAGUATE 11.5.30.422 Pueblo test 3
11.5.29.444
Potentiometric surface projected from well 11.5.14.241 (L-Bar 2)
RIO PAGUATE
BEND IN SECTION
10.5.3.224 Jackpile 5
10.6.8.134 Housing 1
10.5.14.234 Sinkhole
PAGUATE RESERVOIR
SECTION A-A'
BEND IN SECTION
RIO SAN JOSE 9.5.12.442 Mesita test
RIO SAN JOSE
ARROYO CONCHAS
RIO SAN JOSE
RIO SAN JOSE
RIO SAN JOSE
Potentiometric surface in upper sandstones of the Morrison Formation
Approximate potentiometric surface in the San Andres Limestone and Glorieta Sandstone
Water table
Collapsed zone above Todilto Formation
Qal
Kmd
QTi
Jm
Jb
Js
Jt
Je
Ꞃc
Psg
Py
Qb
STRUCTURAL GEOLOGY HIGHLY GENERALIZED
EXPLANATION
CORRELATION OF MAP UNITS
Qal Qb QUATERNARY
QTal QTb QTi QTs QUATERNARY OR TERTIARY
Kmv Kmd CRETACEOUS
Jm Jb Js Jt Je JURASSIC
Ꞃc TRIASSIC
Psg Py PERMIAN
LIST OF MAP UNITS (See plate 2 for description of units)
Qal ALLUVIUM
Qb BASALT
QTal ALLUVIUM
QTb BASALT
QTi IGNEOUS INTRUSIVES
QTs SANTA FE GROUP
Kmv MESAVERDE GROUP
Kmd MANCOS SHALE AND DAKOTA SANDSTONE
Jm MORRISON FORMATION
Jb BLUFF SANDSTONE
Js SUMMERVILLE FORMATION
Jt TODILTO FORMATION
Je ENTRADA SANDSTONE
Ꞃc CHINLE FORMATION
Psg SAN ANDRES LIMESTONE AND GLORIETA SANDSTONE
Py YESO FORMATION
CONTACT--Dashed where approximately located
FAULT--Shows relative movement. Dashed where approximately located.
POSSIBLE DIRECTION OF GROUND-WATER FLOW

Figure 3

control ponded water. The duration of the monitoring program will be a minimum of ten years."

The two pits, North and South Pits are in the twice a year monitor phase (determined as by the EIS final and the ROD). Figure 4 is a photo looking east from the top west edge of the south pit. The monitor well is indicated by an arrow. Saturation into the fill by water is reportedly occurring at the north pit but not at the south pit (Jim Olsen, Nov. 93). Saturation is an indication of how water is refilling into the area after extensive dewatering and interruption of the water bearing units. Saturation is good in one aspect in that the water is returning to the area. However, saturation to the point of ponds developing in the pits is a potential health hazard. The backfill is placed a minimum of ten feet over the exposed ore to protect from ambient exposure. Also the backfill is put in place in an effort to prevent the groundwater to seep to the surface where it might begin collecting in ponds. The ponds would likely contain contaminants which would not meet federal regulations.

The north pit is located near the Rio Paguate and northeast of the south pit (refer to Map 1). Rio Paguate in the area of North Pit contributes seepage into the formations in that area. South pit is located northeast of the P-10 underground mine area. The slow recharge rate of water in the south pit is likely impacted by the extensive extraction of Jackpile Sandstone during underground

FIGURE 4

mining, this observation was confirmed by Reclamation Manager, Jim Olsen.

II. Discharge and Recharge

A. Dewatering with Impacts

An impact which caused loss of water in the Jackpile sandstone unit was dewatering for access into underground mines. Dewatering is the process of pumping water out of the ore layer to increase the strength of the rock. Drainage of the saturated ore body usually takes place before the uranium ore is recovered." (Water Quality Data Report, 1980, pg 8). Water was reported to have been extracted from the P-10 mine to an unlined holding pond directly east of the P-10 mine. The average rate of discharge in 1977 was reported as 150 gpm per day and in 1979 discharge declined to 104 gpm per day.

During 1978, discharge from the Jurassic aquifer averaged about 250,000 gallons per day during 1978 (Risser and Lyford).

Risser and Lyford also reported the following statement in their report:

> "The large open pits have permanently changed the geological composition of the area of the Jackpile mine. [One well] tested in the Jackpile sandstone, declined 25 feet from December 1974 to December 1977. Decline was partly in

response to mine dewatering from Anaconda's underground workings. . . . The water level decline in the [same well] from 1959 to 1979 was about 102 feet. Apparently even before the start of underground mining in 1974, the water level had declined, probably as a result of ground water discharging into the pits excavated for the surface mining that began in the early 1950's (Risser and Lyford Report, pg. 17).

B. Wetlands

A wetlands area is present in the alluvium of the Rio Paguate, located just immediately west of the village of Paguate, between the village and the rio paguate. Wetlands generally are areas with rich soil and more concentrated water accumulation. Dry periods occur, usually in the winter. The significance of wetlands are characterized by unique vegetation that grows in the organically rich soil. Additionally, wetlands act as a filter for water seeping from higher elevations or from aquifers to a moving body of water.

"Groundwater of the alluvium along the Rio Paguate is hydraulically connected to streamflow in the Rio Paguate and the bedrock aquifers that bound the valley fill. . . . Groundwater is withdrawn for public supply in this area [between the Village of Paguate and the Rio Paguate on the southwest side of the village] at an average rate of 30 gallons per minute. More wells withdrawing water at a combined rate of as much as 250 gpm might lower the water table and decrease the water lost to transpiration, which might dry up the marshy area and eliminate the wetland." (Lyford and Risser, 1984, p.41)

A natural wetlands was said to have existed in the alluvium of Rio Paguate near Chinatown by a local resident. Refer to map 1 in back flap for location of China Town).

> "Before the mine there was a marshy area over there near where Chinatown is (refering to a photo on file at the Laguna Library). We used to have fruit trees and the fruit was so delicious, so sweet. Since the mine, the marshy area dried up and the fruit trees died."
>
> -- Elizabeth Waconda, Village Paguate Native

III. Water Quality

This sub-section of the report will evaluate only uranium and radium levels in the ground and surface water of the Jackpile Mine and Mesita Reservoir area. "Concentrations of uranium and radium as well as other trace elements were generally less than permissible established in national drinking-water regulations or New Mexico ground-water regulations. Trace elements that could pose water problems because of their association with uranium ores are lead, selenium, iron, manganese, molybdenum, vanadium, radium and uranium." (<u>Hydrology and Water Quality</u>, BLM #854226)

The following table is the permissible limits for safe drinking water set by the Federal and State governments. There is not a Federal limit for Uranium, which would have jurisdiction for the permissible standards at Laguna Pueblo. The State standards have been considerably higher than the Federal standards in the other readings (only radium is shown). Notice in the example shown, permissable radium level is six times more than the federally agreed level.

Trace element	Federal Limit *(1)	State Limit *(2)
Radium (Ra), picocuries per liter	5.0	30
Uranium (U), milligrams per liter	No federal limits have been set for what is passable.	5

*(1) National Primary Drinking Water Regulations (US EPA, 1977).
*(2) New Mexico State Ground Water Regulations (NM Water Quality Control Commission, 1982).

Figure 5 and 6 are levels of radium and uranium concentrations found in and near the mine site. Figure 5 is from the <u>Final Environmental Impact Statement</u> and Figure 6 is from <u>Hydrology and Water-Quality Monitoring Considerations, Jackpile Uranium Mine, Northwestern New Mexico,</u> USGS Water-Resources Investigations Report 85-4226.

Each of the tables indicate that the uranium and radium levels in surface water are higher after passing through the mine site.

FIGURE 5

RADIUM AND URANIUM IN SURFACE WATERS IN AND NEAR THE MINESITE

Location	Ra-226[a]	Natural Uranium[b]
Rio Paguate (upstream)	0.35	0.006
Rio Moquino (upstream)	0.28	0.008
Ford Crossing (downstream)	3.73	0.239
Paguate Reservoir	1.03	0.236

Source: Momeni, et al. 1983.

Notes: [a]Measured in picocuries per liter.
[b]Measured in milligrams per liter.

FIGURE 6

Sampling site	Uranium (milligrams per liter)	Radium-226 (picocuries per liter)
Rio Paguate upstream from mine area	0.008	0.36
Rio Paguate upstream from confluence with Rio Moquino	.160	3.89
Rio Moquino upstream from mine area	.007	.34
Rio Moquino upstream from confluence with Rio Paguate	.051	1.73
Rio Paguate at ford crossing downstream from mine area	.266	4.31
Paguate Reservoir	.210	1.18
Well 4	.005	.54
New shop well	.008	2.19
Old shop well	.112	2.13
Well P10	.0036	.82

According to the State and Federal Limits, the samples show high levels, but are below the standards.

There are twenty two monitor wells currently in place checking the quality and recharge of water in the Jackpile Mine area. The monitor well sites are located through out the mine site area. The Final Environmental Impact Statement, October 1986, calls for twice annual checks on water quality and water recharge, for ten years after the start of reclamation and once a year after the ten year phase is completed. After the reclamation monitoring of twice a year is complete, then the mine site will be monitored once a year. Official samples are taken and recorded in November and May to fulfill the monitoring requirement.

According to the reclamation manager, Jim Olsen, there has been "no change" in the concentration of sediments checked. Presumably this means since the studies with findings reported in the Final Environmental Impact Statement, October 1986. Additionally, Mr. Olsen reported that the water analysis taken was "within standards." Since this is indian land, standard having jurisdiction would be the federal standard.

Summary

There are several concerns regarding the ground and surface water after the reclamation phase is complete. A primary hydrologic concern is that oxidation may occur in the surface area of rock fragments in the backfill and waste piles. The studies reviewed of the mine site prove to display no data regarding the quality of water passing through the waste rock. Naturally, water from waste rock will discharge to adjacent streams and adjacent aquifers, principally the alluvium and the Jackpile sandstone.

The information reviewed and presented on water lead to the conclusion that the highest concentrations of radium and uranium are found in the water of the Mesita Reservoir. Use of the land other than to support agriculture or livestock is recommended as the uncertainty regarding potential health risks exists.

Summary Recommendations

This report examines potential land uses for the reclaimed Jackpile-Paguate uranium minesite, elements effecting the reclamation, and potential associated health risks. These aspects of land use at the mine site indicate the need to monitor the integrity of the protective shale and sandstone cover and identify and address contaminant levels downstream at the Mesita Reservoir. Currently, livestock are grazing in the area of the reservoir. Thus, a possible pathway for human consumption of radium and uranium is present. Activity which leads to consumption of water by livestock or wildlife at the reservoir is strongly discouraged. Immediate attention needs to be focused on lowering the risks associated with contaminated sediment in the Mesita reservoir. Based on conversations with Allen Sedik, BIA, there are current plans to remove the salt cedar and establish a wildlife refuge at the reservoir. Because of our research, we believe the Pueblo should consider the level of ionizing radionuclides deposited in the reservoir sediment and the associated health risks to anyone removing the salt cedar, to wildlife frequenting a refuge, and to area residents through possible consumption of ducks. It is reported that duck feathers are desirable by residents for ceremonial purposes (Conversation with Richard Luarke). The area of the reservoir might be reclaimed relatively inexpensively by constructing a wetlands. This could produce vegetation which would absorb the contaminants in the sediment. Yet, contaminated vegetation from the constructed wetlands can create a radiation pathway through ingestion.

Whatever decisions the Pueblo makes with regard to the land use of the Mesita Reservoir, considerations of how the reclaimed minesite will be used can now include the experience of the people of the Pueblo of Laguna, the physical aspects of land use presented in this paper, and the potential health hazardous due to long term exposure to ionizing radiation.

Endnotes for Section I

[1] Final Environmental Impact Statement, U.S. Department of the Interior, Bureau of Land Management, and Bureau of Indian Affairs, Albuquerque, New Mexico, October 1986, pg. 1-6. These regulations are published standards for Leasing of Tribal Lands for Mining, Surface Exploration, Mining and Reclamation of Lands, and Operating Regulations for Exploration, Development and Production.

[2] Cost Optimization on the Jackpile-Paguate Reclamation Program, Dr. Charles C. Reith, Mr. Raoul Portillo, Dr. Jere Millard, Dr. Douglas Gonzales, Jacobs Engineering Group, Inc., Albuquerque, New Mexico, 1989, pg. 3.

[3] Ibid., pg. 2.

[4] Final Environmental Impact Statement, U.S. Department of the Interior, Bureau of Land Management, and Bureau of Indian Affairs, Albuquerque, New Mexico, October 1986, pg. 2-69.

[5] Biotic and Abiotic Processes, T.E. Hakonson, L.J. Lane, E.P. Springer from Deserts as Dumps?, edited by Charles C. Reith & Bruce M. Thomson, University of New Mexico Press, Albuquerque, New Mexico, 1992, pp. 119 and 138.

[6] Ibid., pp. 112 and 113.

[7] Ibid., pg. 111.

[8] Ibid., pg. 107.

[9] Introduction to the Radioecology of Forest Ecosystems and Survey of Radioactive Contamination in Food Products from Forests, Andre Fraiture, Commission of the European Communities, Belgium, 1992.

[10] Health Implications of Radionuclide Levels in Cattle Raised Near U Mining and Milling Facilities In Ambrosia Lake, New Mexico, Sandra C. Lapham, M.D., M.P.H., Jere B. Millard, Ph.D., and Jonathan M. Samet, M.D., M.S., Pergamon Press, Health Physics Society, March 1989, Volume 56, Number 3, pg. 327.

[11] Introduction to the Radioecology of Forest Ecosystems and Survey of Radioactive Contamination in Food Products from Forests, Andre Fraiture, Commission of the European Communities, Belgium, 1992.

[12] Jackpile-Paguate, Uranium Mine Reclamation Project, Record of Decision, U.S. Department of the Interior, Bureau of Land Management, Bureau of Indian Affairs, Albuquerque, New Mexico, December 1986, pg. 8.

Endnotes for Section I (continued)

[13] Southwest Miners' Indigenous Conference, September 23rd and 24th, 1993, Village of Paguate, Laguna Pueblo.

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Cost Optimization on the Jackpile-Paguate Reclamation Program, Dr. Charles C. Reith, Mr. Raoul Portillo, Dr. Jere Millard, Dr. Douglas Gonzales, Jacobs Engineering Group, Inc., Albuquerque, New Mexico, 1989, pg. 3.

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Health Implications of Radionuclide Levels in Cattle Raised Near U Mining and Milling Facilities In Ambrosia Lake, New Mexico, Sandra C. Lapham, M.D., M.P.H., Jere B. Millard, Ph.D., and Jonathan M. Samet, M.D., M.S., Pergamon Press, Health Physics Society, March 1989, Volume 56, Number 3, pg. 327.

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Jackpile-Paguate, Uranium Mine Reclamation Project, Record of Decision, U.S. Department of the Interior, Bureau of Land Management, Bureau of Indian Affairs, Albuquerque, New Mexico, December 1986, pg. 8.

Bibliography for Section II

Lyford, Forest P. and Dennis W. Risser, Water Resources on the Pueblo of Laguna, USGS Water-Resources Investigations Report 83-4038. Albuquerque, New Mexico, 1983.

Jackpile-Paquate Uranium Mine Reclamation Project; Final Environmental Impact Statement, Volumes 1 and 2, 1986. Bureau of Land Management and Bureau of Indian Affairs, Albuquerque District Offices.

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Water Quality Data for Discharges From Uranium Mines and Mills in New Mexico; New Mexico Health and Environment Department, Environmental Division Water Pollution Control Bureau, July 1980.

APPENDIX A

APPENDIX B

Readings on Health Risks Associated with Uranium Mining

Specific to the Jackpile-Paguate Minesite
(Taken from the Final Environmental Impact Statement, 1986, pg. 3'9.)

The primary sources of radiation at the Jackpile-Paguate minesite are the radioactive isotopes formed by the decay of uranium-238 in the remaining ore and waste materials at the site. Specifically, these are: uranium-238, uranium-234, thorium-230, radium-226, radon-222, lead-210, polonium-210, bismuth-214, and lead-214. Although other sources of radiation exist, the amount of radiation emitted at the minesite from these other sources is so small in comparison with radiation from the uranium-238 series that the other sources need not be considered here.

The principal pathways by which people may be exposed to radiation from the minesite are: 1) external exposure which results from radiation emitted from airborne radioactive material in the air and ground deposited radionuclides and from gamma radiation emitted from residual ores on the minesite; 2) internal exposure to radiation from radioactive material inhaled into the lungs; and 3) internal exposure to radiation from radioactive material ingested with drinking water and foodstuffs. The major ingestion pathway for radionuclides would be the consumption of locally raised meat.

Health effects include somatic effects (diseases affecting an individual during his lifetime; primarily cancer) and genetic effects (disorders affecting offspring of the irradiated individual).

Regional

(Taken from Uranium Development in the San Juan Basin Region, Final Report, A Report on Environmental Issues by the San Juan Basin Regional Uranium Study, U.S. Department of the Interior, Albuquerque, New Mexico, 1980, pp. IV-53, IV-54, IV-38, IV-39, IV-42)

The Special Radiation Risks of Miners

Miners run a much greater potential health risk from exposure to radiation than does the general public. Two kinds exposure exist: 1) penetrating gamma radiation, and 2) alpha emitting radon daughters which are inhaled and enter the bronchial passages. The latter exposure is by far the more serious. Radon released from the ore decays through several short-lived nuclides to long-lived radioactive lead-210. Excessive accumulation of radioactive particulates in the lungs increases the risk of cancer.

In the early days of uranium mining, high grade ore was often found close to the surface. Small operations of 2 to 30 men proliferated; anybody with a Geiger counter or pickax could stake and open a claim. The risks were mostly unsuspected by those who worked these mines. Shafts and drifts were small, tunnels often dry and dusty, and radiation monitoring practically nonexistent. As a result, the incidence of lung cancer was extremely high among the miners of these so-called "dog" or "coyote" holes.

The larger operations conducted by major corporations, by contrast, often monitored radiation and maintained records. Based on these records, a study covering the period from 1950 to 1968 compared the respiratory cancer deaths of uranium miners with those expected by other hard-rock miners. For the study sample of 3,366 non-uranium, hard rock Caucasian miners, 11.71 deaths caused by respiratory cancer could be expected. Among 3,366 Caucasian uranium miners, by contrast, 70 died of respiratory cancer, six times as many (Lundin, et al, 1971). Among non-Caucasian miners, the impact was less conclusive (1.76 deaths expected, 3 observed). The study also showed that the longer the exposure, the greater the chance of cancer. A related paper mentioned that most of the deaths occurred 10 years or more after exposure began (Lundin, et al, 1969). This report also contained the interesting observation that smoking uranium miners could expect to contract lung cancer at a rate of 10 times greater than that of non-smoking miners.

Ongoing studies of the cancer risks from radiation are expected to reduce the uncertainties in calculations of health effects.

The Impact on Health in the San Juan Basin

Cancer studies and statistics for isolated groups or population segments particular to the San Juan Basin are meager at best. Based on the available estimates of radon source terms and on lung cancer statistics from other population groups, a crude estimate of the general health impact is obtained. Cases of lung cancer may be postulated to result from uranium development at the Moderate level during the year 2000. These cases would not be expected to be manifested until many years later. However, they can be compared with natural incidence of cases that would occur in the year 2000. It must be remembered that the figures in the table* are for one year and the accumulative totals would be the sums of all years considered. Tables appear on the next page.

* Emanations from the Jackpile and the small St. Anthony open pit mines were not considered in this analysis of 1990 and 2000 regional effects. It is anticipated that they would add, at most, the equivalent of one additional mine's emissions.

Table IV-19

LUNG DOSES FROM RADON PROGENY INHALATION ESTIMATED FOR POPULATIONS IN THE YEARS 1990 AND 2000 AS A RESULT OF MODERATE URANIUM DEVELOPMENT

	1990			2000		
		Person-WLM/year			Person-WLM/year	
Communities	Population	Background	Uranium Develop.	Population	Background	Uranium Develop.
Municipalities (14) in the San Juan Basin	148,672	4,460	1,085	181,217	5,437	1,718
Navajo Reservation	126,209	3,786	533	155,815	4,674	1,443
Villages (14) in the Eastern Navajo Agency	27,356	821	337	33,779	1,013	574
Other residents of the San Juan Basin	71,981	2,159	236	91,189	2,736	640
Sub-Total, SJB	374,218	11,226	2,191	462,000	13,860	4,375
Albuquerque	461,772	13,853	793	568,202	17,046	1,459
TOTAL	835,990	25,079	2,984	1,030,202	30,906	5,834

Source: Schiager, 1979, No. 40, revised 1979.

Table IV-20

ESTIMATED LUNG CANCER RISK IN THE YEAR 2000 FROM MODERATE URANIUM DEVELOPMENT SAN JUAN BASIN

		Postulated lung cancer cases*		
Communities	Lung Dose Increase as % of Background	Annually from all causes ($4x10^{-4}$/person-yr)	Annually from nat. bkgd. radon conc. ($8x10^{-4}$/pers-WLM)	Commited from 1 yr of uranium develop. ($8x10^{-4}$/pers-WLM)
Municipalities (14) in the San Juan Basin	31.6%	72.49	4.35	1.37
Navajo Reservation	30.9%	62.33	3.74	1.15
Villages (14) in the Eastern Navajo Agency	56.7%	13.51	0.81	0.46
Other residents of the San Juan Basin	23.4%	36.48	2.18	0.51
Sub-total, SJB	-	184.81	11.08	3.49
Albuquerque	8.6%	227.28	24.72	1.17
TOTAL	-	412.09	35.80	4.66

* Calculations are based on national statistics; they provide a basis for comparisons but should not be construed as applying specifically to the population of the San Juan Basin.

Source: Schiager, 1979, No. 40, revised 1979.

APPENDIX B

APPENDIX B

Glossary

Ambient; A term referring to conditions in the vicinity of a reference point, usually related to the physical environment (ex., the ambient temperature is the outdoor temperature).

Background level; In air pollution studies, the concentration of a pollutant that would exist in the absence of the particular source under study; a "standard" against which the contribution of the particular source can be compared.

Background radiation; The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements.

Curie; A curie measures the radioactivity level of a substance; i.e., it is a measure of the number of unstable nuclei that are undergoing transformation in the process of radioactive decay. One curie equals the disintegration of 3.7×10^{10} (37 billion) nuclei per second or approximately the rate of decay of one gram of radium.

Depletion; as in water supply consumptively used and no longer available as a water source.

Detrital; made up of loose material resulting from disintegration or wearing away.

Discharge; rate of flow at a given instant in terms of volume per unit of time. With respect to water underground, the movement of water out of an aquifer.

Dissolved solids; chemical compounds in solution.

Dose; an amount of radiation absorbed.

Dose commitment; the total dose that an organism is expected to receive during its lifetime from a given quantity of radioactive material deposited in the body.

Ecology; the totality or pattern of relations between organisms and their environments.

Electron; an elementary particle consisting of a charge of negative electricity and having a mass when at rest, of 1/1837 that of a proton.

Element; any of more than 100 fundamental substances that consist of atoms of only one kind and that singly or in combination constitute all matter.

Energy; the capability of doing work.

Fugitive dust; a type of particulate emission made airborne by forces of wind, man's activities, or both, (ex. unpaved roads, construction sites, tilled land or windstorms).

Gamma radiation; short wavelength electromagnetic radiation emitted in the radioactive decay of certain nuclides. Gamma rays are released energy belonging to the same family of electromagnetic radiation as light, ultra violet, radio waves, etc.

Half-life; time required for a radioactive element to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.

Ion; an atom or group of atoms that carries a positive or negative electric charge as a result of having lost or gained one or more electrons.

Ionization; the process by which a neutral atom or molecule acquires a positive or negative charge.

Nuclide; any species of atom that exists for a measurable length of time. A nuclide can be distinguished by its atomic weight, atomic number, and energy state. The term is used synonymously with isotope. A radionuclide is the same as a radioactive nuclide, a radioactive isotope, or a radioisotope.

Particulate; any liquid or solid particles suspended in or falling through the atmosphere.

Radon; a heavy, radioactive, zero-valent gaseous element, formed by the disintegration of radium. Radon-222 emanates from radium; half-life = 3.823 days; and an alpha particle emitter.

Facts about Radiation

(Taken from the Final Jackpile-Paquate Environmental Impact Statement, October, 1986).

Radiation is the transmission of energy through space. Many kinds of radiation exist -- including visible light, microwaves, radio and radar waves, and x-rays. All of these are electromagnetic radiations because they consist of a combined electrical and magnetic impulse traveling through space. Although much of this radiation (e.g., light) is vital to us, it can also be harmful; prolonged exposure to ultraviolet radiation from the sun can cause sunburn or even skin cancer.

Energy can also be transmitted through space by the motion of particulate radiations. These are either one of the fundamental particles of atoms (protons, neutrons, and electrons) or are a simple combination of the three fundamental particles.

The class of radiation of concern in evaluating the health risks of the material at the Jackpile-Paguate minesite is "ionizing" radiation. Ionizing radiation consists of either waves or particles with sufficient energy to knock electrons out of the atoms or molecules in matter. This disruption is termed "ionization."

The simplest example is the ionization of a single atom. The "nucleus," or center of the atom, is composed of particles called "protons" and "neutrons", the proton having a positive charge and the neutron having no charge. Negatively charged particles called "electrons" orbit the nucleus and are held in place by the attraction between the positive and negative charges. A neutral atom contains exactly the same number of electrons as protons, balancing the positive and negative charges.

When ionizing radiation knocks out an electron from an atom, the atom is left with a positive charge while the free electron is negatively charged. These parts of the atom are chemically active and react with neighboring atoms or molecules. The resulting chemical reactions are responsible for causing changes or damage to matter, including living tissue.

Types of Ionizing Radiation

Three common types of ionizing radiation are gamma rays, and alpha and beta particles.

Gamma rays are pure energy without any weight (or mass). Because they do not have any mass, they can pass through the free space in many atoms and through relatively thick materials before interacting. When gamma rays come into contact with living cells, they prove most destructive because of their high energy.

Beta particles are electrons moving at high speeds, some approaching the speed of light. They transmit energy as kinetic energy, and can travel up to 15 feet in air. Having comparatively small mass and a negative charge, their penetration through matter is intermediate between the alpha particle and the gamma ray.

Alpha particles are positively charged. Alpha particles have more mass than beta particles and gamma rays. Alpha particles do not easily pass through the spaces between atoms and lose energy quickly. If an alpha particle produced by radioactive material is inhaled or ingested into the body, it may cause many ionizations in more sensitive tissue.

Health Effects of Radiation

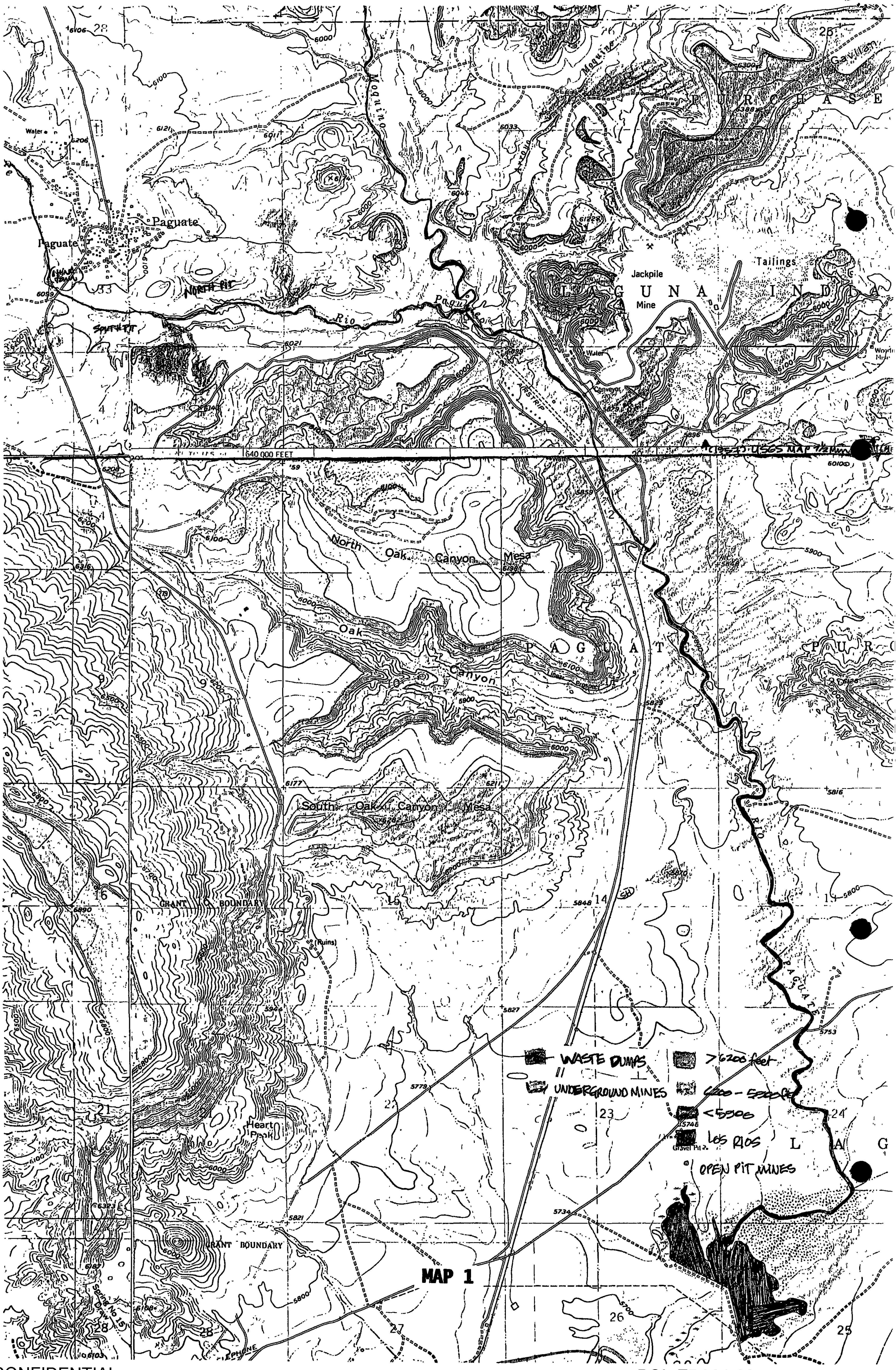
If molecules vital to the function of a cell are ionized by radiation, the cell may be destroyed; if enough cells are destroyed, an organ may be damaged. However, organ damage is usually associated with large doses and is generally referred to as a "short term" effect of radiation.

People who receive high radiation doses also increase their risk of developing cancer and producing genetic damage to their progeny; these are "long-term" effects. The risk is proportional to the dose. How low-level exposure to radiation results in cancer is not fully understood, and the relationship between the amount of exposure and the probability that cancer will develop depends on many variables.

Radiation levels around uranium mine sites are not generally considered to be high enough to cause short-term effects. Radiation levels may be significant enough to raise the risks of "long-term" effects, depending on conditions and length of exposure.

Background Radiation

"Background" is the term used to represent the natural levels of radiation (radioactivity) that are typical for an area. Naturally occurring radioactive elements are present in air, water and soil. Background radiation results from cosmic and terrestrial sources. Cosmic radiation originates in the cosmos and enters the earth's atmosphere, while terrestrial radiation originates from the naturally occurring radionuclides in the soil. The level of background radiation in any particular area depends on such factors as altitude, local geology and meteorological conditions.


Paguate
NORTH PIT
SOUTH PIT
Rio Paguate
Jackpile
Mine
Tailings
PURCHASE
LAGUNA INDIA
640 000 FEET
North Oak Canyon Mesa
Oak Canyon
PAGUATE
South Oak Canyon Mesa
GRANT BOUNDARY
Heart Peak
(Ruins)
WASTE DUMPS
> 6200 feet
UNDERGROUND MINES
< 5900
LOS RIOS
OPEN PIT MINES
Gravel Pit

MAP 1